TECHNICAL REPORT RS-81-2

MICROELECTRONICS AVAILABILITY FOR THE ARMY'S MISSILES

Charles E. Riley
Engineering Directorate

15 September 1980

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35809

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

DISPOSITION INSTRUCTIONS

WHEN THIS REPORT IS NO LONGER NEEDED, DEPARTMENT OF THE ARMY ORGANIZATIONS WILL DESTROY IT IN ACCORDANCE WITH THE PROCEDURES GIVEN IN AR 380-5.

DISCLAIMER

THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION UNLESS SO DESIGNATED BY OTHER AUTHORIZED DOCUMENTS.

TRADE NAMES

USE OF TRADE NAMES OR MANUFACTURERS IN THIS REPORT DOES NOT CONSTITUTE AN OFFICIAL INDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL HAR[illegible] SOFTWARE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TR-RS-81-2	2. GOVT ACCESSION NO. AD-A095 379	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MICROELECTRONICS AVAILABILITY FOR THE ARMY's MISSILES		5. TYPE OF REPORT & PERIOD COVERED Technical
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles E. Riley		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander US Army Missile Command ATTN: DRSMI-RS Redstone Arsenal, AL 35898		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Commander US Army Missile Command ATTN: DRSMI-RPT Redstone Arsenal, AL 35898		12. REPORT DATE 15 September 1980
		13. NUMBER OF PAGES 10
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Microelectronics
Semiconductor technology
Integrated circuit market
Military electronics
Emergency mobilization

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Our modern Army is critically dependent on high technology and in particular sophisticated electronics. Microcircuit technology is the "brain-trust" of our advanced weapon systems. Because of the central role that microelectronics plays in the total acquisition, and maintenance of the Army's weapon systems, it is extremely important that the Army have ready access to this technology. However, the semiconductor industry is not motivated toward serving this need and therefore potential supply problems exist in this area.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

The Army's needs in the area of microelectronics are unique. They cannot be satisfied with off-the-shelf standard products produced by the large semiconductor manufacturers. Rather, they are typically low volume, high reliability, military standard components -- some of which have the added requirement of radiation hardening.

There are three major issues which affect the availability of military electronics: the possibility of modifying commercial-oriented processing lines; the enhancement of existing facilities and the development of new ones aimed at the production of military standard components; and the mobilization of the microelectronics industry, should the need arise.

In this report the many facets and ramifications which impact the cause/effect relationships among the various factors of this very timely problem will be discussed.

In summary, MICOM has developed a sound policy for insuring the availability of its required custom microelectronics. It has accomplished this primarily through the MM&T program which is the catalytic agent which produces an economical manufacturing arena capable of ultimately reducing the cost of hardware in the field.

CONTENTS

I. INTRODUCTION

Our modern Army is critically dependent on technology and in particular sophisticated electronics. Microcircuit technology is the "brain-trust" of our advanced weapon systems. Because of the central role that microelectronics plays in the total acquisition and maintenance of the Army's weapon systems, it is extremely important that the Army have ready access to this technology. However, the semiconductor industry is not motivated toward serving this need and therefore potential supply problems exist in this crucial area. Electronics is not the only area of modern technology where supply problems exist. For example, the required quantities of optics and castings are also not readily accessible. In fact, the total production base which supports the Army's readiness capability is either slowly vanishing or rapidly redirecting its efforts toward other more lucrative markets.

The Army's needs in the area of microelectronics are unique. They cannot be satisfied with off-the-shelf standard products produced by the large semiconductor manufacturers. Rather, they are typically low volume, high reliability, military standard components – some of which have the added requirement of radiation hardening.

Ready access to the microelectronic components required for the Army's weapon program is a problem of enormous importance and its impact extends from the laboratory to the battlefield. Although the problem is examined from a US Army Missile Command (MICOM) point of view, it is characteristic of the entire DoD community.

There are three major issues which affect the availability of military electronics: first, the possibility of modifying commercial-oriented processing lines; second, the enhancement of existing facilities and the development of new ones aimed at the production of military standard components; and third, the mobilization of the microelectronics industry, should the need arise.

In the following material the many facets and ramifications which impact the cause/effect relationships among the various factors of this very timely problem will be discussed.

II. HISTORICAL PERSPECTIVE

It is both interesting and informative to examine some of the historical developments surrounding the availability problem since they provide a view of the environment in which the problem resides.

The semiconductor manufacturing industry is itself in the midst of being violently restructured. According to a special report,[1] this restructuring has linked almost all independent semiconductor manufacturers to major equipment companies. For example, in 1979, Schlumberger Ltd bought Fairchild Camera and Instrument Company and United Technologies Corporation bought Mostek Corporation. These two acquisitions alone involved a capital outlay of almost three-quarters of a billion dollars. In addition, 20 such acquisitions have been made in the last three years. As a result of this trend, it is anticipated that by the mid-1980's one-third of the integrated circuits produced will be designed or built by users rather than suppliers.

According to a recent publication[2], the worldwide integrated circuit market scene is shown in Figure 1. The computer/data communications business has expanded to the point that it consumes a staggering 44% of the worldwide integrated circuit (IC) merchant market. The computer revolution continues and the pace accelerates as the industry moves simultaneously toward bigger computers with smaller microelectronic units. The

1. *Business Week*, December 1979.
2. *STATUS 80, A Report on the Integrated Circuit Industry*, edited by Mel H. Eklund and William I. Strauss, Integrated Circuit Engineering Corp., 1980, Scottsdale, Arizona.

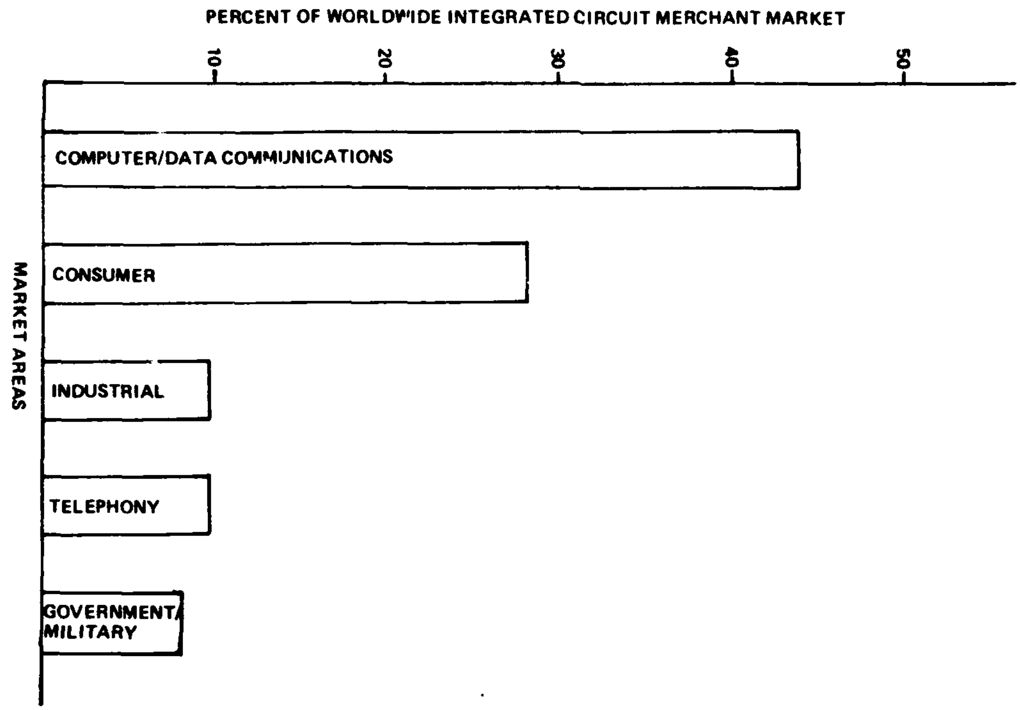

Figure 1. World-wide integrated circuit merchant market.

application of semiconductors to data communications seems almost limitless. The application consumes a major share of the market for such things as switching equipment, carrier, and key systems. The industrial portion of the market, which is directed toward process control and instrumentation, is composed primarily of microprocessors and analog/digital and digital/analog conversion units. The sales volume of these units appears to be growing exponentially with time.

There has literally been a virtual explosion in the consumer uses for microelectronics, and industry is in full production in an attempt to fulfill this insatiable demand. Semiconductors have become an integral part of calculators, watches, games, and toys. Even the automotive industry is undergoing an electronic revolution. Innovative ideas aimed at employing microelectronics in a myriad of consumer products surface every day, and why not! What other area of technology is so extremely useful and yet continues to experience decreasing costs with increasing performance. For example, in 1981 the circuit cost of storing data will be about one-tenth of what it was in 1975 as shown in Figure 2. Figure 3 displays the reliability performance which has been achieved in the progression to large scale integration (LSI). A mere cursory analysis of these data is sufficient to realize what a truly outstanding job industry has done in the production of microelectronics. Productivity continues to increase and this increase is reflected in the performance/cost index of products.

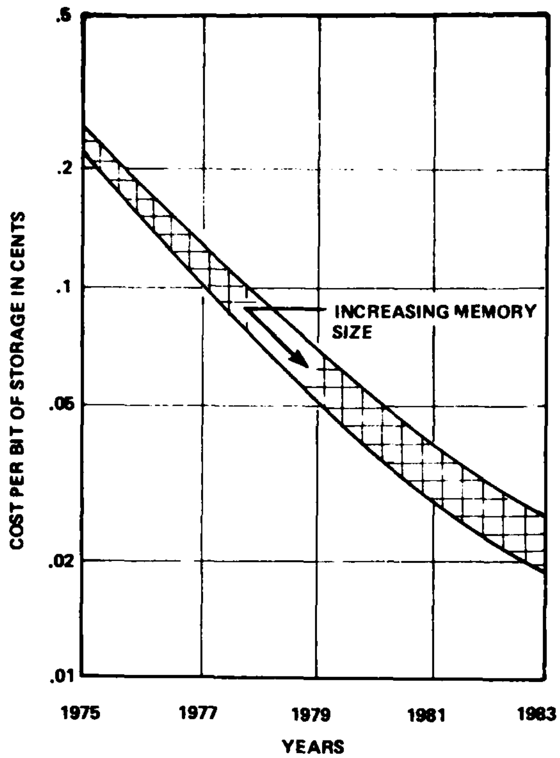

Figure 2. Decreasing cost of random access memory resulting from advances in semiconductor technology.

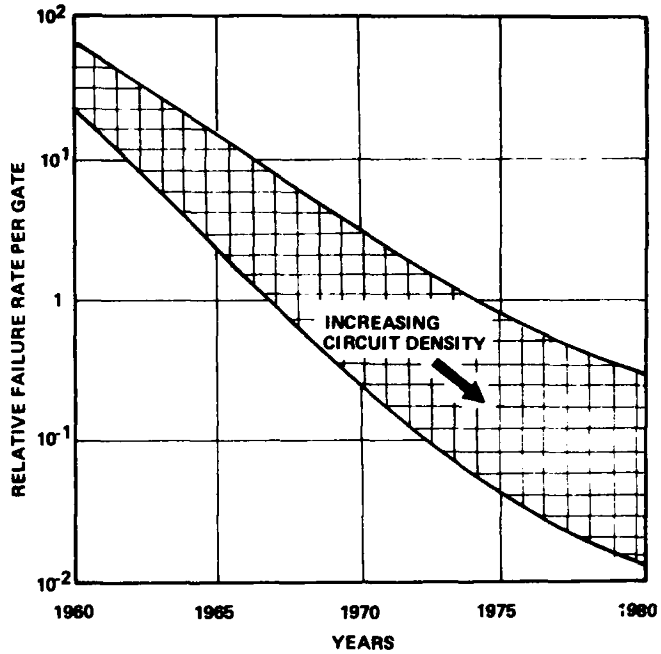

Figure 3. Reliability increases resulting from advances in semiconductor technology.

Foreign countries are making substantial gains in semiconductors – an area which in the past was totally dominated by US industry. For example, the Japanese have pulled out all the stops in attacking semiconductor markets and have currently managed to snatch approximately 55% of the four-thousand bit random access memory (4K RAM) market. Japan's world-wide technological position is not an accident but rather a calculated result of the employment and further enhancement of techniques learned from American industry many years ago. For 15 years the Japanese have been methodically working toward a trident goal – superior levels of automation, productivity, and quality control, all of which they believe are highly interrelated. They currently have approximately one-half the robotic production systems in the world and quality control is the hallmark of every production line. They believe that quality control is a state of mind and a responsibility of leadership and therefore it permeates their organizations from the production apprentice to the president of the company.

The Japanese industry's vigorous pursuit of the worldwide semiconductor market is significantly enhanced by at least two effective methods –– tax incentives and favorable loan policies of the bank of Japan. For example, the government funding of a joint very large scale integration (VLSI) development facility will undoubtedly significantly enhance Japan's technological base while simultaneously fueling the modernization of its semiconductor industry. In this manner the Japanese government has provided a vehicle for its industry to easily enter a market where the initial development costs are enormous. This subsidizing mechanism is designed to propel Japan to a global leadership position, and history would indicate that it is rapidly approaching that goal.

III. AVAILABILITY OF MILITARY ELECTRONICS

A. Typical Problem Areas

MICOM's experience in the microelectronics arena has been most illuminating and clearly indicates the types of problems which are symptomatic of the availability issue.

The Army is experiencing long lead times in the procurement of many components. For example, at present the bare chips used for one military system have delivery times of 50-60 weeks. These long delivery periods result from the fact that suppliers have little interest in government business because the return on investment is not attractive, there is too much paperwork involved, and their processing lines have to be changed from their normal standard product type production to one which produces devices which are carefully tested and inspected to comply with government standards.

Another system employs a welded wire capability for nickel/copper. In the welded wire module all components must have nickel leads. Because of the continuous advances in semiconductors, components are no longer available in this form and microelectronics companies are not interested in building this 10-year old technology.

The ground equipment for a particular missile system employs a flatpack which contains an electronic gate. However, at the present time the device is no longer available in the proper configuration for placement on the printed circuit card, and the newer high speed gates, which are potential replacements, are affected by spurious noise signals which had no impact on the original electronic gate.

New systems are designed to use LSI circuits because of the significant advantages in cost, size, and reliability which would accrue through the use of this technology. These devices are generally not minimum-time production items. However, they are state-of-the-art components. Nevertheless, the large semiconductor companies are unwilling to commit engineering talent to a task which is viewed as a "small" government procurement.

The coproduction problem, i.e., licensing of foreign companies to produce some of our military-grade semiconductors does not appear to be a serious one at the present time because the sophisticated electronics is furnished to foreign countries. The US currently has the capability to supply these components and does so to maintain control. However, the pressure is continuously mounting to allow foreign companies to produce this electronics. This trend takes on added significance in light of the fact that a significant portion of US industry is not actively pursuing government work.

Finally, in view of the historical relationship between the military and the US semiconductor industry, the potential for mobilizing this industry in case of emergencies becomes an issue of significant importance. From a military point of view, mobilization may become a necessity. However, to achieve this mobilization, if necessary, the many facets of such a transition must be thoroughly and carefully examined.

B. Major Issues Affecting Availability

1. Modification of Commercial-Oriented Processing Lines

Industry is not currently oriented toward meeting DoD's current and future needs. Efforts are directed toward producing integrated circuits for high volume commercial applications, thereby permitting high initial design costs to be written off over many production units. The requirements for commercial applications are not oriented toward qualifying integrated circuits for military environments, e.g., high temperature, or developing them with clock speeds high enough to perform the current and projected real time, high speed signal processing functions required in modern quidance systems. Defense-oriented integrated circuits typically require special testing procedures. In addition, on-chip, built-in test, and the use of fault tolerant techniques are absolute requirements in order to provide acceptable logistics costs to the military.

From a commercial perspective, military electronics is a low volume business. However, the applications require the ultimate in performance. Therefore, there is little motivation on the part of industry to spend sizable research and development funds which would ultimately yield a low return on investment. For example, it is estimated that the same number of engineers in a microelectronics manufacturing company can design two military chips with an expected volume of 20,000 per year or 10 commercial chips with an expected volume of 120 million per year. In view of these figures, one can hardly fault industry for taking the tack it has. Industries are in business to make money and if they do not operate in a profit mode to supply the market demands, the market will consume them.

Therefore, the military finds itself in a rather precarious position. Its requirements are too specialized to allow for the employment of off-the-shelf products, and its volume is too low to interest the big semiconductor manufacturers who are not only producing standard products at breakneck speed, but are planning for the development of new commercial markets.

However, once the design is complete, there exists a large degree of commonality between the processing techniques employed for commercial and military-grade semiconductors. The process modifications necessary to produce military products are not unreasonable and are centered primarily in the testing phases.

Tightly coupled with this strategy is the issue of coproduction. There is no doubt that this concept is viable from a foreign viewpoint. However, one must carefully assess what could be a negative impact on the US military production base and the fragile supply lines which could exist in emergency situations.

On the other hand, however, one can also speculate that if foreign companies successfully expand into the commercial market, then the military may become more attractive to US semiconductor firms, thus enhancing the military production base.

The reality of the situation, however, is that even without the military market, there exists insufficient capacity to meet the commercial demands for microelectronics. Therefore, a time and economic analysis of the conversion scheme from commercial to military products is in order. Such a conversion involves two items, design and processing. Because many military designs are strictly custom, commercial designers must be reoriented and retrained for military applications. It would take a minimum of 12 months and nominally 24 months to change a commercially-oriented design team into one that is truly effective for military applications. Approximately 10 companies and 300 to 500 experienced microelectronics design engineers would have to be retrained to be capable of defining, learning, and implementing military requirements into design. Assuming the cost of one man-year with burden to be $100,000, the cost for labor in the conversion of design would be 30 to 50 million dollars. However, there will also be a major task involving design software conversion and this will cost an additional 10 to 15 million dollars over the one to two-year time frame. Therefore the total cost for design conversion is 40 to 65 million dollars respectively, over a one to two-year time frame.

There exists some commonality between processes for commercial and military products. Assuming yield degradation would not be counted as an expense and that useless specifications would not be enforced, it would take approximately one to two hundred process/manufacturing engineers, 12 to 24 months to make the conversion. This would cost 10 to 20 million dollars. Equipment modification, e.g., adjustments of ion implantation, would cost 5 to 10 million dollars. Therefore, the total conversion time would be from one to two years at a cost of from 55 to 95 million dollars. It is also important to keep in mind that the semiconductor manufacturers would be willing to make the conversion only in a true state of national emergency.

2. Enhancement of Custom Fabrication Facilities

Facilities dedicated to the production of custom microelectronics are of extreme importance to the military. They are needed for both the development of new weapon systems which employ state-of-the-art devices and the maintenance of field-deployed systems which employ more mature electronic technologies.

The aerospace industry recognizes the extreme significance of electronics. The industry fully realizes that microelectronics is the optimum vehicle by which very complex and high performance electronic packages can be developed within the space and performance requirements imposed by modern missile systems. However, at the present time there appears to be a growing divergence between the military and commercial technological goals. This deviation in emphasis has caused major problems for defense contractors who depend upon specialized electronic companies or vendors to provide components for missile controls, avionics, and smart munitions. To fill this void in component availability, many large defense contractors have restructured their organizations to develop the in-house capability for design, development, and production of the microelectronic components required to satisfy contract demands.

In the case of missile systems, the development time is so long and advances in microelectronics technology are so fast that parts cannot be obtained for maintenance of these systems when they are deployed. Production lines have been dismantled and changes made to reflect the newest technology. Even with built-in testing and repair capability, which complicates the design phase, there is an inevitable need for spare parts. Thus, dedicated custom fabrication facilities, capable of producing and repairing a variety of electronic technologies, are necessary ingredients for supporting the total military electronic needs.

Such dedicated facilities are typically GOCO (government owned and contractor operated) plants. The cost of a typical GOCO facility for microelectronics is approximately 20 million dollars and approximately one year is required to bring such a facility on stream. However, this facility, once in line, would be capable of supplying the latest in technology as well as the components needed for maintenance in a relatively short period of time.

3. Development of a Mobilization Strategy

The US semiconductor industry has done an absolutely remarkable job in producing high quality, low cost microelectronics for commercial uses, and it has managed to do this in the absence of certain types of government help, such as tax incentives. Although industry's apparent lack of interest in military electronics is understandable and even predictable in light of the economics involved, it would indeed be possible to convert this awesome industrial might into a highly efficient military supplier should the need arise. Assuming no nationalization of industry or mass diversions of plants or personnel, the problems involved in a mobilization, with the exception of time, do not appear to be very difficult. Industry currently has the personnel, equipment, and technology required to support military electronics, and in a national emergency these organizations would unquestionably redirect their efforts to supply the necessary items. Most major semiconductor companies build their military products on the same processing lines which are used for commercial and consumer products. It is typically the screening and testing of components that separates the military products from the others. Radiation hardened technology is also available but there are fewer companies which possess expertise in this area because of its limited interest. To mobilize this industry, however, government and industry must work in close cooperation to develop a detailed transition plan which serves the interest of both. The most critical factor for mobilization is planning. This is an absolute necessity for which there is no substitute. Government simply must meet with industry leaders now and lay out a step-by-step contingency plan to define the problem areas and conceive a strategy for solving them. This will involve identification of components, pipelines, weak links, stockpiles, and the like. The plan must identify capabilities together with a specified time frame. A time frame for conversion, which is unquestionably long in this context, together with the attendant cost has been previously identified.

Because of the long time required in the conversion, it is extremely important that those industries which currently supply military electronics be well supported in efforts to insure that those supply lines are immediately available. For modern systems, components are currently being made. Therefore, the problem in this case is capacity and quantity. However, for older but useable systems, obsolescence is a problem. Components required may no longer be available and thus alternative designs should be conceived and established. This task would require one to three years and cost from 5 to 20 million dollars. Obviously, for mobilization it is time that is the critical factor.

IV. THE MICOM STRATEGY

The US Army Missile Command is keenly aware of the major issues which impact its ability to obtain the types and quantities of semiconductors that are required to sustain its development programs and to maintain its field deployed systems. It is also aware that the large military and aerospace contractors have slid from a premier market position where they accounted for 70% of the semiconductor sales to a position where they cling to only 7 to 8% - a percentage decrease of almost an order of magnitude. Within this framework, however, MICOM is diligently pursuing the problems which impede its ability to obtain the components it needs. This is obviously a multifaceted issue with tentacles which extend into the depth of both government and industry. MICOM intends to vigorously support those organizations which are currently working to solve these problems and to pave the way for other industry to join the attack. Specifically, MICOM has developed an integrated philosophy involving a total cradle-to-grave approach for microelectronics. The Command is committing both resources and time to provide significant support for industry in this area so that advanced manufacturing technology can be applied on the production floor as soon as possible. This approach, which involves a coordinated effort from research through the manufacturing methods and technology (MM&T) program to production, is designed to increase productivity, guarantee availability and decrease costs.

The major weapon employed by MICOM in this approach is the judicious and strategic use of the MM&T program. Through this program MICOM supports the following critical developments designed to minimize the problems inherent in the availability of custom electronics:

(1) Manufacturing techniques for multiple chips employing multiple technologies that are not only currently in vogue but are projected to be in the mainstream of the semiconductor marketplace for many years to come,

(2) Electronic computer-aided manufacturing (ECAM) and hybrid aided design and manufacturing (HYCADAM) to automate microelectronic production lines and therefore improve productivity, increase fabrication speed and decrease per unit costs, and

(3) Elimination of precious metals from military hybrid microcircuits and their replacement with viable materials which are universally available and economically attractive.

One alternative to the solution of these problems is to implement a cooperative arrangement between the large semiconductor companies and the major aerospace industries to maximize the delivery of components by optimizing the tasks performed by each, e.g., wafers supplied by a semiconductor company would be totally inspected, tested, packaged, and qualified by an aerospace contractor.

The techniques developed under this program will not only significantly enhance the ability to produce the types and quantities of low volume, highly diverse, customized high technology components, but will attempt to exploit in every way possible the high quality, commercially-oriented product lines. This program, which attempts to stimulate industry to invest its own capital for process innovation, is akin to the technology modernization (TECH MOD) program currently being spearheaded by the Air Force for DoD.[3,4]

MICOM's strategy also involves contingency efforts for mobilization in emergencies. Scenarios are being examined which provide the necessary advanced planning data. Under examination are technologies such as digital processes, e.g., complimentary metal oxide semiconductor (CMOS), linear processes, e.g., bipolar, dielectric isolation, and radiation hardened, together with the companies which possess expertise in these areas.

An analysis indicates that all the necessary ingredients are in place. The importance of this analysis stems from the fact that it is in a mobilization situation that the availability problem becomes absolutely critical.

In summary, MICOM has developed a sound policy for ensuring the availability of its required custom microelectronics. It has accomplished this primarily through the MM&T program which is the catalytic agent which produces an economical manufacturing arena capable of ultimately reducing the cost of hardware in the field.

3. *Business Week*, September 8, 1980.

4. *Government Executive*, September 1980.

DISTRIBUTION

DRSMI-X	1
DRSMI-R	1
DRSMI-RS	15
DRSMI-RPT (Reference Copy)	1
DRSMI-RPT (Record Copy)	1
DRSMI-RPR	15
DRSMI-LP, Mr Voigt	1
DRSMI-RH	1
DRSMI-RL	1
DRSMI-RR	1
DRSMI-RS	1
DRSMI-RT	1
DRSMI-RD	1
DRSMI-RE	1
DRSMI-RK	1
DRSMI-RG	1
DRSMI-V	1
DRSMI-XB	1
DRCPM-CF	1
DRCPM-RS	1
DRCPM-MP	1
DRCPM-HA	1
DRCPM-PE	1
DRCPM-TO	1
DRCPM-HD	1
DRCPM-ROL	1
DRCPM-VI	1

LMED

8